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EXPERIMENTAL STUDY ON MICROSTRUCTURE OF FRICTION STIR WELDING OF AA6061

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ABSTRACT

Friction stir welding is a solid state joining method, widely used for welding the light weight alloys for air craft manufacturing, shipbuilding, automobiles and many other applications of commercial importance. Friction stir welding (FSW) can produce better mechanical properties in the weld zone compared to the old conventional welding methods. Later, the best composition of the material will be selected from test results, and this will be used as the main tool in friction stir welding. The material, which is to be welded, is also made up of same composition used in the tool. Friction stir welding (FSW) can produce sound mechanical properties in the weld zone. The tool gives the functions of heating of work piece, deform the material and movement of deform material to produce the joint. Scanning Electron Microscopy test has been performed to study the microstructure of the FSW produced by our tool. Friction stir welding can be widely applicable in Aircrafts, rockets, automobiles, robotics etc.

KEYWORDS: Metal Matrix Composites, Microstructure, SEM Test & Friction Stir Welding

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Original Article

INTRODUCTION

AA6061 is the aluminium alloy, consists of magnesium and silicon as the major alloying elements [1, 2, 3], as shown in figure 1. It has good mechanical properties and exhibits good weldability.

Figure 1: AA6061 Raw Material

Friction Stir attachment is taken under consideration to be the foremost necessary development in metal matrix of integrity in an extreme decade. Al alloys are going to be joined without making of any difficulty. Without using the filler metal, the properties of the joints are improved compared to the parent metal [2,3]. Friction stir welding can be applied for different butt joints, pipes etc. [4, 5] and Joints with whole {completely totally different} thickness and different profile. Frictions stir attachment is a solid activity of integrity

technique. Friction stir attachment (FSW) can manufacture higher mechanical properties inside the weld zone compared to different typical attachment techniques. In many applications, Al metals or sheets area unit joined by ancient ways like fascinating, nailing etc. By exploitation Friction stir attachment, rather than fascinating, we are going to boot weld the Al materials

FRICTION STIR WELDING

The welding institute (TWI) in 1991 is a solid-state modification of integrity technique. The heating is accomplished by friction between the rotating tools, and thus the plates have undergone for plastic deformation [6, 7]. The developed heat will give the flexibility of the material around the pin and shoulder of tool rotation, because of thermal conductivity, and the results path of material from the front of the pin to the rear of the pin is as shown in figure 2.

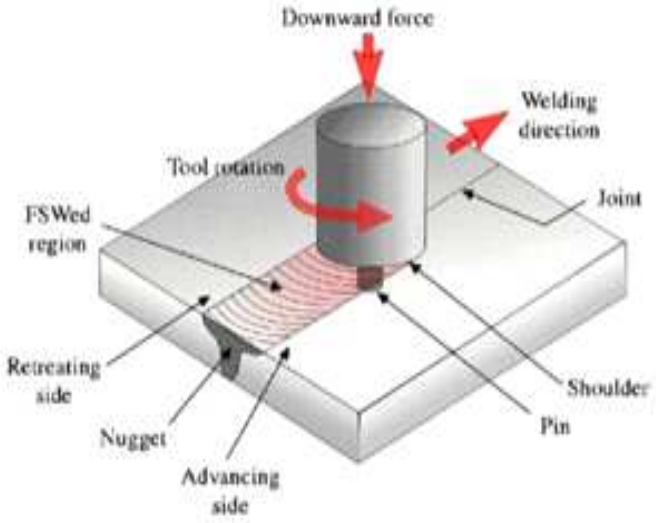


Figure 2: Schematic Diagram of Friction Stir Welding

Friction Stir attachment is taken into account to be the foremost vital development in metal connection in an exceeding decade[8, 9] The connection doesn't involve any use of filler metal, and thus any atomic number 13 alloy is joined without worrying for the compatibility of composition, that is a problem in fusion attachment. However, price effective stirring tools area units are required for attachment of a number of these materials like metal matrix composites, Steels and Ti alloys[10]. In this method, the specially taken into account parameters are tool material, tool shape and profile, tool rotational speed, downward force and weld speed on the joint line, generating heat and that softens a fabric beneath the tool[12,13,14]. The softened material flows around the tool through in depth plastic deformation, and is consolidated behind the tool to make a solid-state continuous joint.

EXPERIMENTAL PROCEDURE

Friction stir welding was performed on AA6061 plates of dimensions 100×50×5(mm). We have taken 4 plates of AA6061 of similar dimensions as shown in figure 3, and two tools made of AA6061+6% Al_2O_3 and H13 as shown in table 1.

Figure 3: AA6061 Metal Plates

After the preparation of availability for friction stir welding process, first of all, the welding fixture was properly fitted on the bed of Vertical Milling Machine and after that, work piece was clamped on the welding fixture with the help of top clamps provided. Side supporting plates are used to support the work piece or to restrict the movement of work piece during the welding operation. After clamping of work piece on welding fixture, tool was clamped in the spindle, then starts the machine and impinges the tool into the work piece up to the desired depth, after that feed was provided to the bed, and friction stir welding was performed.

FSW with AA6061+ 6% Al_2O_3 Tool

Table 1: FSW Process Parameters and Tool Nomenclature AA6061+6% Al_2O_3 Tool

Rotational speed (rpm)	710
Feed rate (mm/min)	30
Pin length (mm)	5
Tool shoulder diameter (mm),D	15
Pin diameter (mm),d	5.7
Tool holder diameter (mm)	22
Tool materials	AA6061+6% Al_2O_3
D/d Ratio of tool	2.63
Load	5000N
Tool Profile	Cylindrical Threaded

Figure 4: Experimental Setup of FSW

SEM Analysis

A scanning Electron Microscope (SEM) analysis will be useful for finding the different zones like TMAZ, HAZ and weld zone this test can give resolution higher than one nanometer Specimens are focused in high vacuum in typical SEM, and at elevated temperatures with specialized instruments.

RESULTS AND DISCUSSIONS

The figures 5(a) and (b) are showing after performing Friction Stir Welding on the plates, $1cm^3$ of welded area is cut and SEM test has been performed on the Samples.

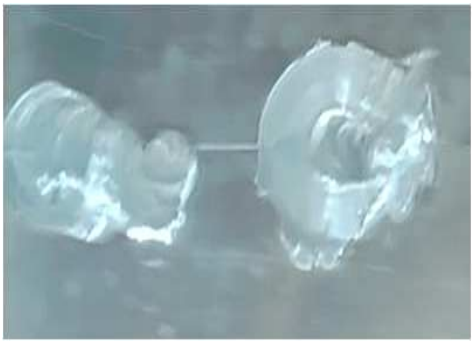


Figure 5(a): Friction Stir Welded Area

Figure 5(b): Friction Stir Welded Area

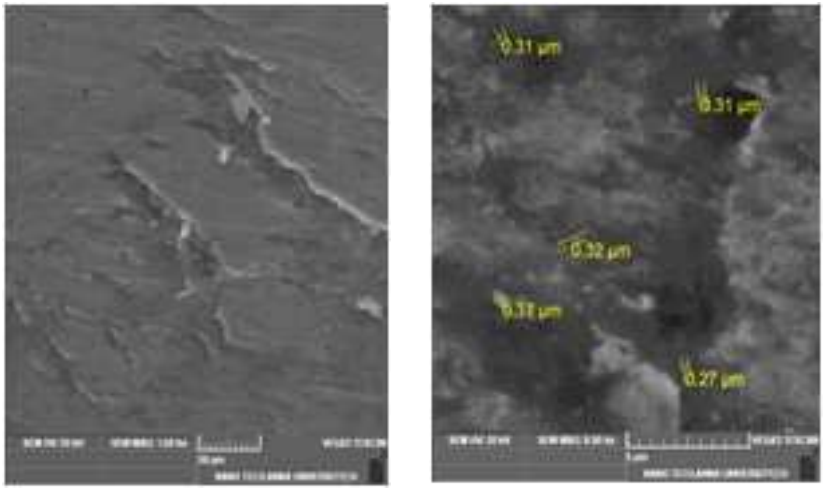
Scanning Electron Microscopic test was performed on the samples as shown in the figure 6, so as to find whether any tool particles were melted and distributed in welded area during Friction Stir Welding This test also determines the changes in grain size of non- welded region and Friction Stir Welded region.

SEM Test has been performed under following conditions.

Filament use: Tungsten, Voltage supplied: 20kV, Magnification Range: 100 to 10000, Sample size: $1cm^3$

Figure 6: Weld Zone Samples

The result of the Microstructure of FSW with AA6061+ 6% Al_2O_3 Tool are as follows; shown in below figure 7(a) and (b).



(a) **(b)**

Figure 7: Microstructure of FSW Weld Zone

- The microstructure of sample welded by AA6061+ 6% Al_2O_3 tool clearly shows that some tool particles were distributed over the welded area. This is due to the meltdown of the tool profile due to high temperature at the welding zone.
- It is also noticed that the friction welding was not reached the bottom of the plate(the opposite side of the welded side)
- We can state that the weld produced by this tool is as strong as the weld produced by other tools, when compared with other ceramic tools.
- We also predict that the weld is non-corrosive, may possess good strengths.
- We can conclude that the present work done is partially successful and paved a way to further research in using similar materials for both tool and work piece, which can be done by heat treatment, coating of tool etc.

CONCLUSIONS

The conclusions made from the present investigation are as follows.

- It was observed that in the friction stir welding process, selection of tool material and design of tool is an important task.
- The results of the SEM Test results were studied and compared with each other.
- Finally, we conclude that the welding done by AA6061+ 6% Al_2O_3 tool is partially successful and this work paved a way for future research on the use of similar material for both work piece and tool, which can be done by various methods like heat treatment, coating with other particles etc.

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